

# Effect of Fertilizer Source on Nitrate Leaching and St. Augustinegrass Turfgrass Quality

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**Abstract.** As a result of the coexistence of turfgrass and ornamentals in traditional landscapes, it is often impractical to separate fertilization and irrigation management among species. Furthermore, limited information is available on effects of turfgrass fertilizer on ornamental plants and vice versa. This research studied effects of two quick-release fertilizers (QRF) and one slow-release fertilizer (SRF) on quality and growth of turfgrass and ornamental plants and nutrient leaching. ‘Floritam’ St. Augustinegrass (*Stenotaphrum secundatum* Walt. Kuntze) was compared with a mix of common Florida ornamentals, including canna (*Canna generalis* L.H. Bailey), nandina (*Nandina domestica* Thunb.), ligustrum (*Ligustrum japonicum* Thunb.), and allamanda (*Allamanda cathartica* L.). All plants were grown in 300-L plastic pots in Arredondo fine sand. Less nitrate ( $\text{NO}_3^-$ ) was leached from turfgrass than from ornamentals and more  $\text{NO}_3^-$  leached from QRF 16N–1.7P–6.6K than from SRF 8N–1.7P–9.9K. Quick-release fertilizers produced higher plant quality. This controlled environment research provides preliminary data on which in situ research may be modeled. Further research is required to verify how nutrient release rate affects turfgrass and ornamental quality and nitrate leaching in an urban landscape.

St. Augustinegrass is a widely used warm-season turfgrass for home lawns throughout the south. St. Augustinegrass prefers moderate cultural practices (Cisar et al., 1992) with a fertility requirement of 10 to 30  $\text{g}\cdot\text{m}^{-2}\cdot\text{yr}^{-1}$  N (Trenholm et al., 2000a). In residential areas, lawn fertilization is often cited as a major contributor to nonpoint source pollution, which may lead to elevated levels of  $\text{NO}_3^-$  in groundwaters. Petrovic (1990) demonstrated that  $\text{NO}_3^-$  has the potential to leach through soils and contaminate groundwater if not properly applied, although other research has shown that properly applied fertilizer is assimilated by the grass (Erickson et al., 2001; Snyder et al., 1984). Proper fertilizer management, including appropriate rates, sources, application timing, and proper irrigation after fertilizing, have all been shown to influence  $\text{NO}_3^-$  leaching (Gross et al., 1990).

Controlled-release fertilizers have been shown to reduce fertilizer leaching from turfgrass (Killian et al., 1966). Brown et al. (1982) observed nitrate losses of 8.6% to

21.9% in golf course greens (bermudagrass, perennial ryegrass, Kentucky bluegrass, tall fescue, and creeping bentgrass) fertilized with ammonium nitrate. When slow-release sources such as isobutylidene diurea and ureaformaldehyde were used, only 0.2% to 1.6%  $\text{NO}_3^-$  was leached. Sulfur-coated urea is often found in turfgrass fertilizers and it is less likely to leach than noncoated urea (Allen et al., 1971).

The typical landscape is comprised of both turfgrass and ornamentals, which often makes it difficult to separate fertilization and irrigation regimes between species. Although research has been done on turfgrass fertilization and its effect on environmental quality, little information is available on effects of turfgrass fertilizer formulations on ornamental plants or the effects of ornamental fertilizer formulations on turfgrass. In a nutrient management study comparing St. Augustinegrass and a mixed landscape planting, Erickson et al. (2001) observed that a greater amount of  $\text{NO}_3^-$  was leached from ornamentals (1.46  $\text{mg}\cdot\text{L}^{-1}$ ) than from turfgrass (less than 0.2  $\text{mg}\cdot\text{L}^{-1}$ ). More than 30% of the applied nitrogen was leached from the ornamentals and less than 2% from the turfgrass.

The objectives of this study were: a) to evaluate qualitative and growth responses of turfgrass and ornamentals to different

fertilizer sources, 2) to evaluate  $\text{NO}_3^-$  leaching from different fertilizer sources, and 3) to compare nutrient leaching of turfgrass versus ornamentals.

## Materials and Methods

The research was performed in a climate-controlled greenhouse at the G.C. Horn Memorial Turfgrass Field Laboratory at the University of Florida in Gainesville. ‘Floritam’ St. Augustinegrass and a combination of ornamentals that included *Canna generalis* L. var. ‘Brandywine’, *Ligustrum japonicum* Thunb. var. ‘Lake Tresca’, *Nandina domestica* Thunb. var. ‘Harbor Dwarf’, and *Allamanda cathartica* L. were established in large plastic pots in May 2002. Pots measured 0.8 m in diameter by 0.4-m tall with a volume of 300 L. Mature St. Augustinegrass sod was harvested from the research field and planted to cover the entire surface area of the pots. Ornamental plants grown in 2.8-L containers were acquired from a retail nursery and one of each species was planted in each ornamental treatment pot.

Pots were placed on reinforced metal tables in the greenhouse. Five centimeters of gravel was placed at the bottom of the pots, and a mesh cloth was placed over the gravel to retain the media. Pots were filled with Arredondo fine sand (loamy, siliceous, hypothermic, Grossarenic Paleudalt). Turfgrass treatments received 2.5  $\text{g}\cdot\text{m}^{-2}$  N, 0.28  $\text{g}\cdot\text{m}^{-2}$  P, and 1.0  $\text{g}\cdot\text{m}^{-2}$  K at 14 d after planting and were then allowed to establish for 6 weeks before treatments began.

There were three fertilizer treatments: quick-release fertilizer (QRF) 16N–1.7P–6.6K (Lesco, Cleveland, OH) (ammonium sulfate, concentrated superphosphate, and potassium chloride), QRF 15N–0P–12.5K (Lesco) (ammonium sulfate and potassium chloride), and a slow-release fertilizer (SRF) 8N–1.7P–9.9K (polymer-coated sulfur-coated urea, ammonium phosphate, and polymer-coated potassium sulfate). Fertilizer treatments were applied six times at 2-month intervals (17 July 2002, 19 Sept. 2002, 20 Nov. 2002, 17 Jan. 2003, 18 Mar. 2003, and 21 May 2003) at a rate of 4.9  $\text{g}\cdot\text{m}^{-2}\cdot\text{yr}^{-1}$  N to both turfgrass and ornamentals. Each of these 2-month periods is referred to as one fertilizer cycle (FC).

Leachate was collected three times during each fertilizer cycle, at 2, 4, and 8 weeks after fertilizer application. To facilitate leachate collection, a hole was drilled into one side of the pot. A 13-mm diameter polyethylene tube was attached to the pot to allow leachate to drain into a dark 19-L plastic bucket. Samples were submitted to the Analytical Research Laboratory in Gainesville for  $\text{NO}_3^-$  analysis. Throughout the study, the volume of total leachate collected was measured. Results are presented based on both nutrient concentration in leached water ( $\text{mg}\cdot\text{L}^{-1}$ ) and total nitrate content leached (mg) over the FC. Nitrate content was calculated by multiplying nitrate concentration with the corresponding leachate volume.

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Turfgrass visual quality ratings were taken weekly on a scale of 1 to 9, with 9 being best, 1 being worst, and 6 being minimally acceptable turfgrass quality. Multispectral reflectance (MSR) readings were taken three times during each FC on turfgrass treatments—at weeks 1–2, 3–5, and 7–8 using a CropScan model MSR 16R (CROPS-CAN, Inc., Rochester, MN). Reflectance was measured at specific wavelengths: 450, 550, 660, 694, 710, 760, 835, and 930 nm. Some important MSR indices are normalized difference vegetation index, measured as  $(R_{930} - R_{660}) / (R_{930} + R_{660})$ , and Stress-1, measured as  $R_{710} / R_{760}$ .

To determine thatch accumulation, three 25.5-cm<sup>2</sup> cores were collected from each turfgrass pot during the first week of May 2003. Cores were 7.6 cm deep. Shoots and roots were removed from the collected plugs, dried for 48 h at 72 °C, and weighed to measure the thatch. Dried thatch was ashed in a muffle furnace (450 °C for 5 h) and organic material weight was determined.

Recently matured leaf tissue samples were collected from both turfgrass and ornamentals in July and Nov. 2002 and Mar. and July 2003. Samples were dried, ground, and analyzed for nutrient concentration (N, P, K, Ca, Mg, Fe, Zn, Cu, and Mn). Analysis of N was done by total Kjeldahl nitrogen procedure and the remaining elements were analyzed with Spectro Ciros ICP (SPECTRO Analytical Instruments GMBH & Co. KG, Kleve, Germany). At termination of the experiment, shoots and roots from each pot were harvested and dried to constant weight at 75 °C. Roots of ornamental plants were excavated and washed but were not separated by plant species as a result of the intermingling of roots.

Turfgrass was mowed every week with scissors to maintain a height of 9 cm and clippings were removed. Cypress mulch was applied to ornamentals at a thickness of 2.5 cm. A micronutrient blend (STEP HiMag; The Scotts Co., Marysville, OH) was applied at a rate of 6.7 g·m<sup>-2</sup> during Sept. 2002 to both turfgrass and ornamentals. To control a minor infestation of armyworm (*Spodoptera* spp.) in turfgrass, 8% bifenthrin was applied at a rate of 4 g·L<sup>-2</sup>. *Ligustrum* were treated with a 2% insecticidal oil during November to control scale (*Hemiberlesia lataniae*) infestation. Irrigation was applied uniformly to both turfgrass and ornamentals as needed over the course of the year.

Experimental design was a randomized complete block with four replications. Data were analyzed with the SAS analytical program (SAS Institute, 2003) to determine treatment differences at  $P = 0.05$  and means were separated with Fisher's least significant difference.

## Results and Discussion

**Visual quality, color, and density.** Higher visual scores in the first 2 weeks after fertilizer applications were obtained with QRF treatments (Table 1). By 3 weeks after treatment application, QRF 15N-0P-12.5K-

Table 1. Turfgrass visual quality in response to fertilizer sources.

Weeks	Fertilizer	Quality	Color	Density
1 WAT	QRF 15N-0P-12.5K	7.1 a <sup>z</sup>	7.2 a	7.1 a
	QRF 16N-1.7P-6.6K	7.0 a	7.1 a	7.0 a
	SRF 8N-1.7P-9.9K	6.6 b	6.6 b	6.6 b
	ANOVA	<0.0001	0.005	0.0002
2 WAT	QRF 15N-0P-12.5K	7.5 a	7.5 a	7.4 a
	QRF 16N-1.7P-6.6K	7.4 a	7.4 a	7.3 a
	SRF 8N-1.7P-9.9K	7.0 b	7.0 b	7.0 b
	ANOVA	0.002	<0.0001	0.0014
3 WAT	QRF 15N-0P-12.5K	7.0 a	7.0 a	6.9 a
	QRF 16N-1.7P-6.6K	6.9 ab	6.9 a	6.8 a
	SRF 8N-1.7P-9.9K	6.7 b	6.7 a	6.7 a
	ANOVA	0.03	0.12	0.12

<sup>z</sup>Means followed by the same letter do not differ significantly at  $P = 0.05$ . Visual scores are based on a scale from 1 to 9, with 9 being best, 1 being worst, and 6 being minimally acceptable turfgrass quality. Means are averaged over six fertilizer cycles (FC).

WAT = weeks after treatment; QRF = quick-release fertilizer; SRF = slow-release fertilizer; ANOVA = analysis of variance.

Table 2. Turfgrass thatch, shoot and root weight in response to fertilizer treatments.<sup>z</sup>

Fertilizer	Thatch dry wt (g·cm <sup>-2</sup> )	Shoot dry wt (g)	Root dry wt (g)
QRF 15N-0P-12.5K	0.150 ay	1082.46 a	161.83 a
QRF 16N-1.7P-6.6K	0.126 b	1069.96 a	168.25 a
SRF 8N-1.7P-9.9K	0.108 c	867.59 b	140.68 a
ANOVA	0.0011	0.048	NS

<sup>z</sup>Weights taken at termination of the experiment.

<sup>y</sup>Means followed by the same letter do not differ significantly at  $P = 0.05$ .

QRF = quick-release fertilizer; SRF = slow-release fertilizer; ANOVA = analysis of variance; NS = not significant.

treated turfgrass had better quality than SRF 8N-1.7P-9.9K-treated turfgrass, but no differences were found in color or density attributable to fertilizer. Beyond 3 weeks after fertilizer application, no differences in color, quality, or density were noted (data not shown). Faster initial release of N from the QRFs produced better turfgrass quality, color, and density. Similar results were noted in bermudagrass [*Cynodon dactylon* (L.) Pers. × *C. transvaalensis* Burt Davy] ultra-dwarf cultivars (Hollingsworth et al., 2005).

**Thatch, shoot, and root growth.** Thatch accumulation was 19% and 39% greater in turfgrass treated with 15N-0P-12.5K than in turfgrass treated with 16N-1.7P-6.6K and SRF 8N-1.7P-9.9K, respectively (Table 2). Greater shoot mass (24% and 23%, respectively) was observed in QRF 15N-0P-12.5K and 16N-1.7P-6.6K-treated turfgrass compared with SRF (Table 2) as a result of the faster rate of N release from the QRFs. No differences were found in root mass attributable to fertilizer treatments.

**Nitrate leaching by concentration (mg·L<sup>-1</sup>).** Averaged across fertilizer treatments, more NO<sub>3</sub><sup>-</sup> leached from ornamentals than from turfgrass at 15 and 60 d after treatment (DAT) and when sampling dates were averaged (Fig. 1). Differences in NO<sub>3</sub><sup>-</sup> leaching were found between turfgrass and ornamentals in FC 2 (Sept. to Nov. 2002), FC 4 (Jan. to Mar. 2003), and FC 5 (Mar. to May 2003) (Fig. 2). In a study in south Florida, Erickson et al. (2001) observed that a greater amount of NO<sub>3</sub><sup>-</sup> leached from ornamentals (1.46 mg·L<sup>-2</sup>) in comparison with turfgrass

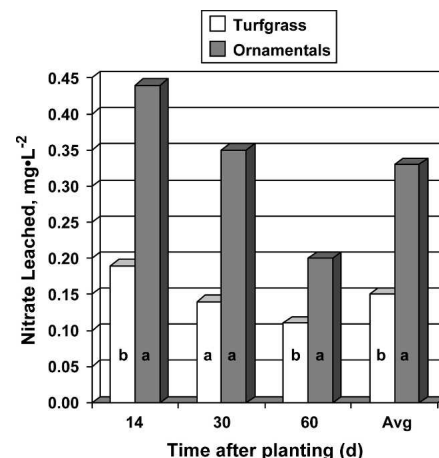


Fig. 1. Nitrate (mg·L<sup>-2</sup>) leaching of turfgrass and ornamentals. Ornamentals included *Canna generalis* L. var. Brandywine, *Ligustrum japonicum* Thunb. var. Lake Tresca, *Nandina domestica* Thunb. var. Harbor Dwarf, and *Allamanda cathartica* L. Bars with the same letter are not different at  $P = 0.05$ . Means are averaged over six fertilizer cycles.

(less than 0.2 mg·L<sup>-2</sup>) and that more than 30% of the applied N was leached from the ornamentals and less than 2% from the turfgrass.

Averaged over both plant treatments, the most NO<sub>3</sub><sup>-</sup> was leached from QRF 16N-1.7P-6.6K and the least from SRF 8N-1.7P-9.9K (Fig. 3). Quick-release fertilizer 16N-1.7P-6.6K leached less NO<sub>3</sub><sup>-</sup> from turfgrass than from ornamentals at 15 and

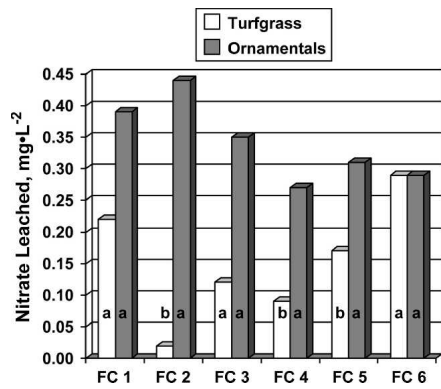


Fig. 2. Nitrate ( $\text{mg}\cdot\text{L}^{-2}$ ) leaching from turfgrass and ornamentals in six fertilizer cycles. Ornamentals included *Canna generalis* L. var. Brandywine, *Ligustrum japonicum* Thunb. var. Lake Tresca, *Nandina domestica* Thunb. var. Harbor Dwarf, and *Allamanda cathartica* L. Bars with the same letter are not different at  $P = 0.05$ . Means are average of three leachate collections per fertilizer cycle.

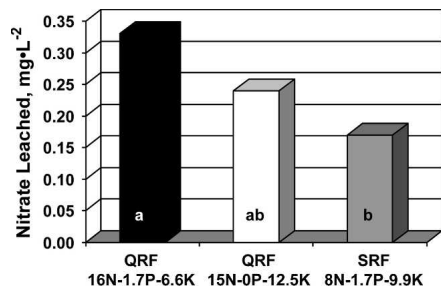


Fig. 3. Nitrate leaching ( $\text{mg}\cdot\text{L}^{-2}$ ) from different fertilizers averaged from both turfgrass and ornamentals. Ornamentals included *Canna generalis* L. var. Brandywine, *Ligustrum japonicum* Thunb. var. Lake Tresca, *Nandina domestica* Thunb. var. Harbor Dwarf, and *Allamanda cathartica* L. Bars with the same letter are not different at  $P = 0.05$ . Means are averaged over six fertilizer cycles.

60 DAT and when averaged overall sampling dates (Table 3). There were no differences in leaching between plant types with QRF 15N-0P-12.5K or SRF 8N-1.7P-9.9K.

**Total nitrate leaching by volume (mg).** There were differences between plant treatments over time for total  $\text{NO}_3^-$  leached from QRF 16N-1.7P-6.6K (Table 4). Turfgrass leached less  $\text{NO}_3^-$  than ornamentals at 15 DAT and when averaged over all leaching events. There were no differences in leaching

Table 3. Nitrate leaching ( $\text{mg}\cdot\text{L}^{-1}$ ) from turfgrass and ornamentals<sup>z</sup> in response to fertilizer treatments.<sup>y</sup>

Fertilizer	Plant	Day 15	Day 30	Day 60	Avg
QRF 15N-0P-12.5K	Turf	0.30	0.19	0.11	0.21
	Ornamentals	0.40	0.24	0.28	0.26
	ANOVA	NS	NS	NS	NS
QRF 16N-1.7P-6.6K	Turf	0.16	0.14	0.11	0.14
	Ornamentals	0.66	0.60	0.28	0.52
	ANOVA	0.01	NS	0.006	0.002
SRF 8N-1.7P-9.9K	Turf	0.13	0.10	0.10	0.11
	Ornamentals	0.28	0.23	0.17	0.23
	ANOVA	NS	NS	NS	NS

<sup>z</sup>Ornamentals included *Canna generalis* L. var. Brandywine, *Ligustrum japonicum* Thunb. var. Lake Tresca, *Nandina domestica* Thunb. var. Harbor Dwarf, and *Allamanda cathartica* L.

<sup>y</sup>Data are averaged over six fertilizer cycles (FC).

QRF = quick-release fertilizer; SRF = slow-release fertilizer; ANOVA = analysis of variance; NS = Nonsignificant.

Table 4. Nitrate leaching (mg) from turfgrass and ornamentals<sup>z</sup> in response to fertilizer treatments.<sup>y</sup>

Fertilizer	Plant	Day 15	Day 30	Day 60	Total
QRF 15N-0P-12.5K	Turf	2.20	0.90	0.87	3.97
	Ornamentals	1.85	0.94	0.61	3.40
	ANOVA	NS	NS	NS	NS
QRF 16N-1.7P-6.6K	Turf	1.10	0.74	0.76	2.60
	Ornamentals	2.67	1.95	1.00	5.62
	ANOVA	0.009	NS	NS	0.01
SRF 8N-1.7P-9.9K	Turf	0.84	0.70	0.68	1.52
	Ornamentals	1.63	1.21	1.00	3.84
	ANOVA	NS	NS	NS	NS

<sup>z</sup>Ornamentals included *Canna generalis* L. var. Brandywine, *Ligustrum japonicum* Thunb. var. Lake Tresca, *Nandina domestica* Thunb. var. Harbor Dwarf, and *Allamanda cathartica* L.

<sup>y</sup>Data are averaged over six fertilizer cycles (FC).

QRF = quick-release fertilizer; SRF = slow-release fertilizer; ANOVA = analysis of variance; NS = Nonsignificant.

between the other fertilizer treatments at any sampling date.

**Leaf tissue nutrient concentration.** There were no differences in leaf tissue nutrient concentration for any nutrients in turfgrass (data not shown). This implies that nutrient uptake is similar regardless of fertilizer source.

**Multispectral reflectance.** Optimal MSR values in the first 2-week period after treatment were obtained with either QRF treatment (Table 5). During the first 2 weeks after treatment application, QRFs released N faster than SRF, resulting in better turfgrass vigor and quality and greater light assimilation. The availability of N has an impact on total chlorophyll content, which can be detected by MSR (Carter, 1993; Carter and Miller, 1994; Trenholm et al., 2000b). At weeks 3 through 5, wavelengths 450 and 710 nm and Stress-1 index had better responses from QRF 15N-0P-12.5K than from SRF 8N-1.7P-9.9K. There were no differences in reflectance through the rest of the FC (data not shown).

## Conclusions

Visual quality scores of both turfgrass and ornamentals were greater in the 2 weeks after fertilizer application with QRF than with SRF. Less biomass production (thatch and shoot weight) was observed in SRF-treated turfgrass. No difference was noticed in leaf nutrient concentration resulting from fertilizer treatments. Less  $\text{NO}_3^-$  was leached from turfgrass than from ornamentals at 15 and 30 DAT. More  $\text{NO}_3^-$  was leached from QRF 16N-1.7P-6.6K than from SRF 8N-1.7P-9.9K when averaged over both plant types and across sampling dates. Multispectral reflectance and visual results indicate that QRFs produce better quality turfgrass for the first 2 weeks after fertilizer application with no differences in visual scores observed after that.

These visual and growth data are typical of turfgrass responses to various fertilizer sources and indicate the relative predictability of turfgrass to fertilizers. Professional lawn care services have often relied on these

Table 5. Multispectral reflectance values in turfgrass throughout the fertilizer cycle (FC).

	WV (nm)	450	550	660	694	710	NDVI	Stress -1
0-2	QRF 15N-0P-12.5K	<b>3.76 a</b> <sup>y,x</sup>	<b>7.83 a</b>	<b>3.82 a</b>	<b>5.07 a</b>	<b>9.71 a</b>	<b>0.86 a</b>	<b>0.24 a</b>
WAT	QRF 16N-1.7P-6.6K	<b>3.71 a</b> <sup>z</sup>	<b>7.80 a</b>	<b>3.71 a</b>	<b>4.99 a</b>	<b>9.63 a</b>	<b>0.86 a</b>	<b>0.24 a</b>
	SRF 8N-1.7P-9.9K	5.18 b	10.33 b	6.06 b	7.54 b	13.51 b	0.79 b	0.33 b
ANOVA	ANOVA	0.0002	0.0018	< 0.0001	< 0.0001	< 0.0004	< 0.0001	< 0.0001
3-5	QRF 15N-0P-12.5K	<b>4.04 a</b>	<b>7.34 a</b>	<b>4.25 a</b>	<b>5.79 a</b>	<b>8.67 a</b>	<b>0.837 a</b>	<b>0.27 a</b>
WAT	QRF 16N-1.7P-6.6K	<b>4.80 ab</b>	<b>8.79 a</b>	<b>4.82 a</b>	<b>6.11 a</b>	<b>11.15 ab</b>	<b>0.832 a</b>	<b>0.29 ab</b>
	SRF 8N-1.7P-9.9K	6.42 b	<b>9.89 a</b>	<b>6.34 a</b>	<b>7.58 a</b>	12.59 b	<b>0.774 a</b>	0.37 b
ANOVA	ANOVA	0.08	NS	NS	NS	0.06	NS	0.03

<sup>z</sup>Means followed by the same letter do not differ significantly at  $P = 0.05$ .

<sup>y</sup>Means are averaged over six fertilizer cycles.

<sup>x</sup>Optimal values in bold.

WAT = weeks after treatment; ANOVA = analysis of variance; QRF = quick-release fertilizer; SRF = slow-release fertilizer; NS = nonsignificant.

responses to provide quick green-up in lawns and achieve client satisfaction. However, environmental implications from fertilizer applications have not often been considered by professional lawn care services. These results indicate that care should be used when applying a QRF such as 16N-1.7P-6.6K, but also indicate the ability of turfgrass to take up applied fertilizer. Although this research provides preliminary data on which in situ research may be modeled, further research is required to determine how nutrient release rate affects turfgrass and ornamental quality and  $\text{NO}_3^-$  leaching in an urban landscape.

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